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PROVISIONAL APPLICATION COVER SHEET

This is a request for filing a **PROVISIONAL APPLICATION** under 37 CFR 1.53(b)(2).

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TITLE OF THE INVENTION (280 characters max.)

LAND GRID ARRAY FABRICATION USING ELASTOMER CORE AND CONDUCTING METAL SHELL OR MESH

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- [ ] Small Entity Statement
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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

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Respectfully submitted,

SIGNATURE Dan Morris Date: October 24, 2002

TYPED or PRINTED NAME Dr. Daniel P. Morris, Esq. Registration No. 32,053

[ ] Additional inventors are being named on separately numbered sheets attached hereto.

PROVISIONAL APPLICATION FILING ONLY

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Land Grid Array Fabrication using Elastomer Core and Conducting Metal Shell or Mesh

Disclosure number YOR8-2002-0489

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Field of the Invention

This invention relates to a method for fabricating Land Grid Array (LGA) interposer contacts that are both conducting and elastic. LGA interposers provide an interconnection between a chip module (eg. MCM) and a printed wiring board (PWB). A general example of an LGA held in place between a module and a PWB is shown in figure 1. LGA's accommodate very dense 2-D arrays of I/O and are currently being used in the highest-end server and supercomputer products.

Background

One prominent commercially available LGA uses button contacts consisting of siloxane rubber filled with silver particles as shown in figure 1. This is intended to provide a contact which has rubber-like elasticity with electrical conductivity. While siloxane itself has very desirable properties for this application, having both a low elastic modulus and high elasticity, the particle filled system looses significant elasticity at the loadings required for electrical conductivity. While the modulus goes up, it remains low overall and requires only about 30 to 80 grams per contact to ensure good electrical reliability. The loss of elasticity, however, results in severe creep deformation under constant load

and stress relaxation under constant strain. These tendencies render conducting elastomer LGAs unreliable for high end products that require extra ordinary stability over time. Indeed, modern high end server CPUs demand LGA failure rates at ppb levels on a per contact basis because of a total system dependence on individual signal contacts.

Because of the creep and stress relaxation demonstrated by the filled conducting elastomer LGAs of the prior art, the industry currently favors LGA arrays fabricated from random coil springs. A product called the Cinch connector made by the company called Synapse. These springs have a much higher spring constant than the conducting elastomer type and require upwards of 120 grams per contact to ensure reliable electrical connection across the array. These forces combine across a multichip module with more than 7000 I/O to require nearly a ton of continuously applied force over the area of a 4 x 4 inch module. These high forces can deform ceramic modules reducing their planarity which can result in cracked die, broken C4 connections, and loss of thermal conductivity to the heatsink by introducing defects in thermal paste.

There is a strong technical motivating factor for using LGAs instead of rigid direct solder attachments between module and board. The lateral stresses that occur due to TCE mismatches between ceramic modules and organic PWBs are large and direct ball grid array type connections often fail. Systems are preferred which have some built in lateral compliance. One direct attach solution to address that problem is the so called "column grid array" or CGA. The CGA is a permanent solder type interconnect that deforms without failing to accommodate the lateral stresses imposed.

There is also strong economic motivating factor for using LGA interposers over direct attach solutions. This is that repairs and upgrades to chipsets cannot be carried out in the field with direct attach solutions. Pressure mounted LGA's can be replaced in the field saving the customer significant cost in disassembly, shipping, and rework down-time. Thus, there are both technological and economic advantages to the pressure applied type LGA interposer approach. No current solutions provide a reliable connection that is either scalable to larger I/O counts or to more fragile organic chip module systems.

This disclosure teaches a device type and methods of fabrication that fulfills both the requirements of high long term reliability, low contact force, and field replacablity.

Summary

This disclosure describes an LGA type that utilizes a pure elastomer button core (unfilled) that is covered with a conducting material that is continuous from the top surface to the bottom surface.

Brief Description of Drawings

Figure 1: Shows a crossection of a module assembly utilizing a pressure-applied LGA. It depicts a conducting siloxane type button contact as used in the Tyco prior art. It utilizes siloxane with silver particles mixed in above the percolation threshold for conductivity. This patent teaches a button type consisting of elastomer without the filler, but instead

with conductor on the outside surface of the button. The module assembly is however consistent with the use of the herein described LGA interposer type.

Figure 2: Illustrates a basic process flow for metallizing the through-hole in the interposer carrier sheet.

Figure 3: Basic process flow for molding elastomer button into pre-metallized LGA carrier sheet.

Figure 4: Continued from Figure 3. Branch method 1 from fig. 3 for metallizing the elastomer button to become the conducting electrical contact.

Figure 5: Continuation of method 1 for metallizing elastomer button - second side of button.

Figure 6: View corresponding to stage of process flow of figure 2 designated as figure 2-A. This is a simple perforated LGA carrier plane with no processing yet carried out.

Figure 7: View of empty interposer also corresponding to stage of process flow of figure 2 designated as figure 2-A.

Figure 8: View corresponding to stage of process flow of figure 2 designated as figure 3-A. The holes have now been metallized with a continuous path from a metal ring around the top surface of the hole, down through the via, to a ring around the bottom surface of the hole.

Figure 9: Illustrates the stage of the process flow of figure 3 designated as figure 3-B whereby the elastomer has been injection molded into the pre-metallized LGA carrier sheet. Both isometric view and detailed crossection shown.

Figure 10: shows the structure of figure 9 in another isometric view.

Figure 11: Illustrates several patterns of metallization that could be fabricated on the outer surface of the elastomer contact button. Figure 11-A shows a minimum metal pattern consisting of a circular metal pad on the top (and bottom not shown) surface with a conducting line leading to the carrier through-hold metallurgy. The metal outer ring delineated only as a co-centric ring is the metal on the carrier plane to which the metal of the elastomer button makes contact for electrical continuity through the hole.

Figure 11-B shows a similar pattern with two such conducting lines leading from the top metal pad down to the through-hole metallurgy, shown as the outer cocentric ring. Figures 11-C through 11-F shows more examples of contacts with a plurality of conducting lines and of varying widths. These range from very few thin lines to many thin lines to very few wide lines. Figure 11-G shows an all-metal cap where the underlying siloxane is not visible. Figure 11-H shows a specialized cap where the entire surface area of the siloxane button is metallized except for a central hole which can be used for optical window in those cases where isolated LGA locations may be populated by a vertical cavity surface emitting laser (VCSEL) for optical signaling instead of a BLM pad for electrical signaling. The unmetallized bands on either side of the central window hole is an artifact of the mask that defined the window.

Figure 12: Shows the crossection of two examples of a physical mask used during metallization of the elastomer contact. In figure 12-A, the masking only protects the non-elastomer portion of the LGA and allows metallization of the full elastic button. A pattern

corresponding to figure 11-G. Figure 12-B shows partial masking of the elastomer itself so that patterns such as 11-A can be formed.

Figure 13: Illustrates how the unmetallized elastomer contacts in the LGA carrier are brought into contact with the mask prior to metallization. Once mated, the metallization can be carried out by vacuum sputtering or evaporation, or by some other means. Then, the mask is removed leaving an array of metallized buttons in the desired pattern.

Figure 14: Illustrates an LGA that has fully metallized elastomer buttons as per the result of figure 13 process steps. This figure is an abbreviated and isometric view of the process flow of figures 4 and 5.

Figure 15: Illustrates an LGA interposer prior to metallization mated with a mask corresponding to the button pattern of figure 11-B.

Figure 16: Illustrates an LGA interpose prior to metallization mated with a mask corresponding to the button pattern of figure 11-E.

Figure 17: Shows a completed LGA interposer with elastic buttons metallized in the pattern of figure 11-H.

Figure 18: Illustrates an alternate method for metallizing the buttons. Instead of using a mask and metallizing via vacuum sputtering or evaporation, the elastomer is pre-seeded with a seed compound for electroless plating of metal. This way the unmetallized interposer can be simply dipped in plating solution and only the contacts will become metallized.

Detailed Description

In one embodiment

A land grid array interposer is fabricated to have a non-conducting polymer carrier plane which is perforated in a grid pattern. One hole for each contact button. Each hole is then metallized so that a continuous electrical path is formed from a concentric metal ring around the top surface of the hole, down through the via, and to a concentric ring around the bottom surface of the hole. These holes are then filled by injection molding to form barbell or otherwise shaped button contacts with elastomer. All contact buttons are made simultaneously by injection molding of an elastomeric compound, such as for example siloxane rubber. This array of buttons is then metallized in any of several ways. The most straightforward method, constituting the preferred embodiment, utilizes a contact mask whereby the non-button areas of the LGA are protected by the mask, as are some select areas on the button. The metallization is carried out, for instance by vacuum sputtering, and then the mask removed. The metal covers only the desired portions of the contact button. The LGA is flipped over to the other side, the mask is applied, metallization of the second side carried out, and then the mask is again removed.

This provides an LGA interposer which has excellent conductivity from the top of the button to the bottom of the button, which is highly elastic, which has low restoring forces, and which does not suffer from the undesirable plastic deformation and creep of the filled elastomer systems of the prior art.

While this type of contact will have a large TCE (800ppm) because of the pure elastomer button, it is of no consequence since the restoring force will be maintained at high levels throughout its use lifetime. It is only when restoring forces become diminished in the buttons of the prior art because of creep and stress relaxation that TCE pullback was of sufficient dimension to cause the undesirable transition from compression to open circuit.

An advantage to having a ribbed metal contact instead of a continuous shell, is that the stresses incurred during compression of the contact during use can be distributed away from the conducting metal and in doing so preserve the structural integrity of the button to higher contact loads and more extreme conditions. The uncontained elastomer between the conducting ribs can bulge out without inflicting damage or undue stresses to the conductors.

Reduction to practice.

Prototypes of these LGAs have been made using the mask method.

Claims

Claim 1: A land grid array interposer which consists of pure elastic contact button (not metal particle filled.) interiors and conducting metal exteriors.

Claim 2: An LGA of claim 1 where the carrier sheet is perforated on a regular grid and where the perforation holes are pre-metallized to have a metal ring on the top surface

oriented concentrically to the hole and where the metallization is continued into the vertical via and then continued to a metal ring on the bottom surface of the hole.

Claim 2: An LGA where the elastomeric button consists of siloxane.

Claim 3: An LGA where the outer surface of the button is a continuous shell of conducting metal.

Claim 4: An LGA where the metallization is carried out by vacuum evaporation or vacuum sputtering of the buttons while a physical mask is in contact with the LGA.

Claim 5: An LGA where the metallization is carried out by electroless plating of a metal in a plating solution, and where the plating occurs only on the contact button and not on the LGA carrier as dictated by the presence of a seed compound (like palladium or tin seed for gold electroless plating) which was pre-mixed with the elastomer before injection molding.

Claim 6: An LGA where the metallization is carried out in a pattern on the elastic button so that some areas of the button remain unmetallized and available to bulge out in response to compression of the button during actuation during use.

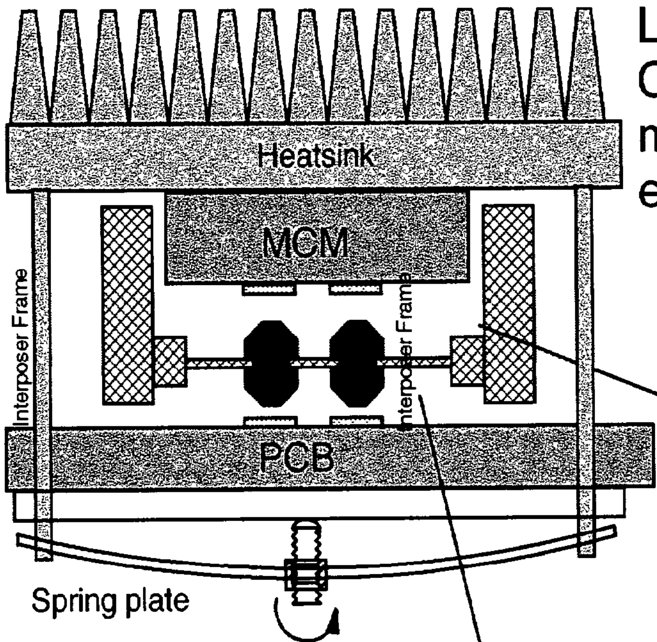
Claim 7: A metallization pattern on the button contact which excludes a center portion thus allowing it to act as an optical window for optical signal transmission instead of electrical transmission. This is in anticipation of future module types that will mix electrical signal sites on the bottom of a chip module with optical signal sites where a vertical cavity surface emitting laser (VCSEL) will be in place of the BLM.

Figures for disclosure YOR8-2002-0489

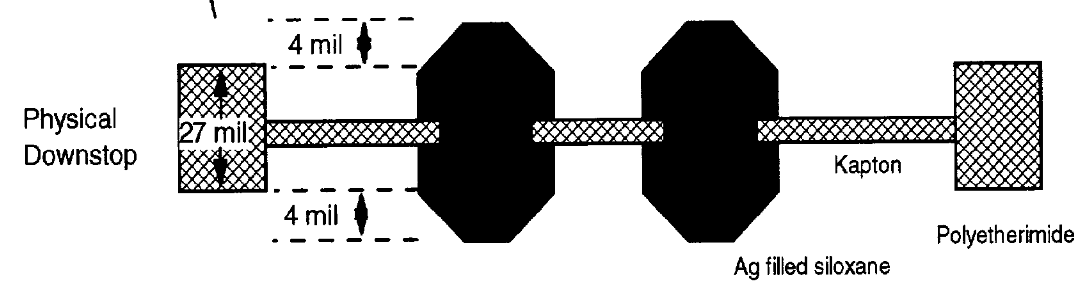
"Land Grid Array Fabrication using Elastomer Core and Conducting Metal Shell or Mesh"

Gareth Hougham,
Keith Fogel,
Paul Lauro

Figure 1 Background Information



LGA Interposer shown in the context of use. Conducting elastomer LGA interposer connects chip module to printed wiring board. (typically though not exclusively)



Illustrative Dimensions of Interposer. Shown with example two contact buttons on a side rather than more typically 40 and more.

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Figure 2: Basic process flow for metallizing through-hole in interposer carrier sheet

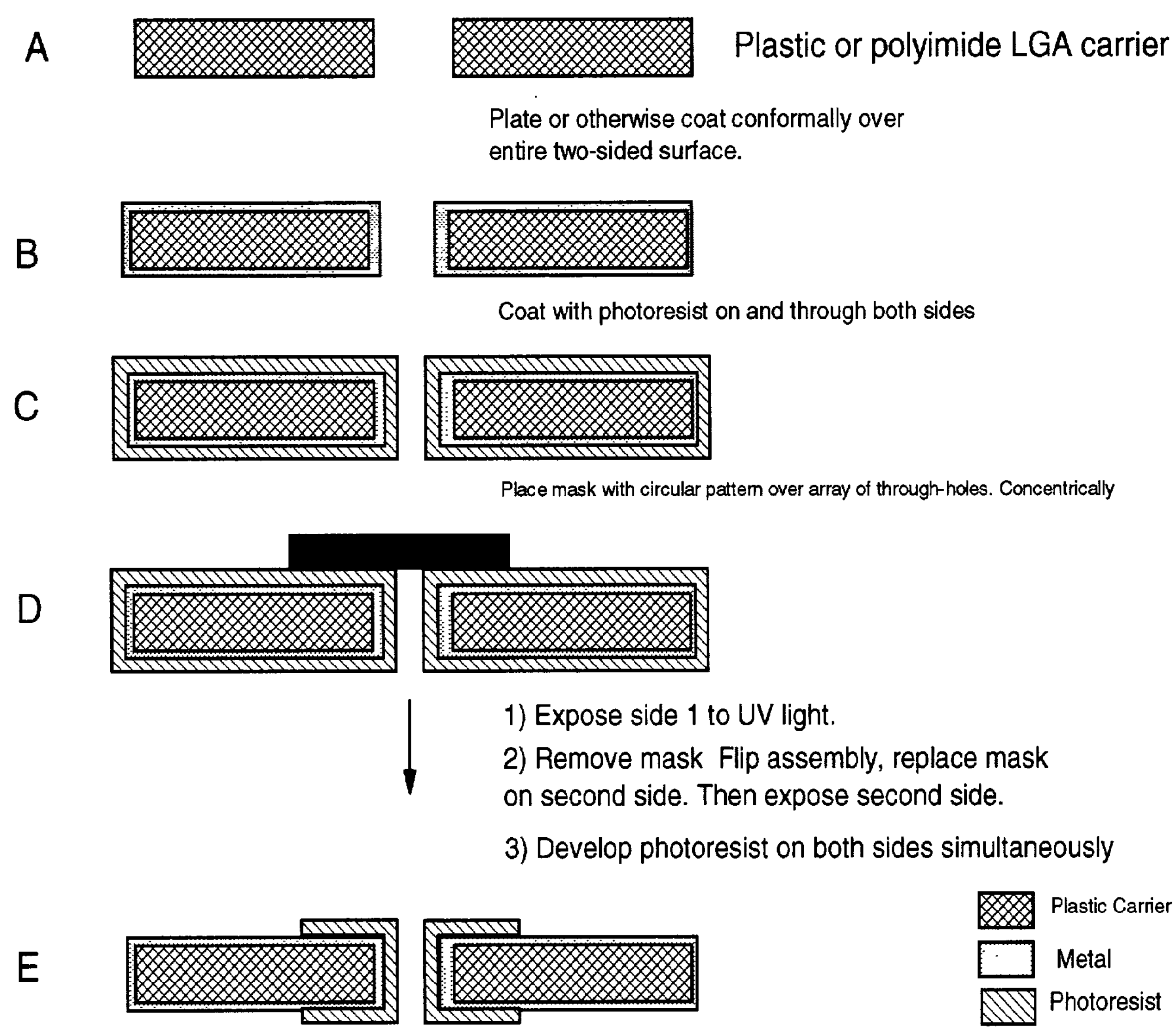


Figure 3: Basic process flow for molding elastomer button into pre-metallized LGA carrier sheet

(continued from figure 2)

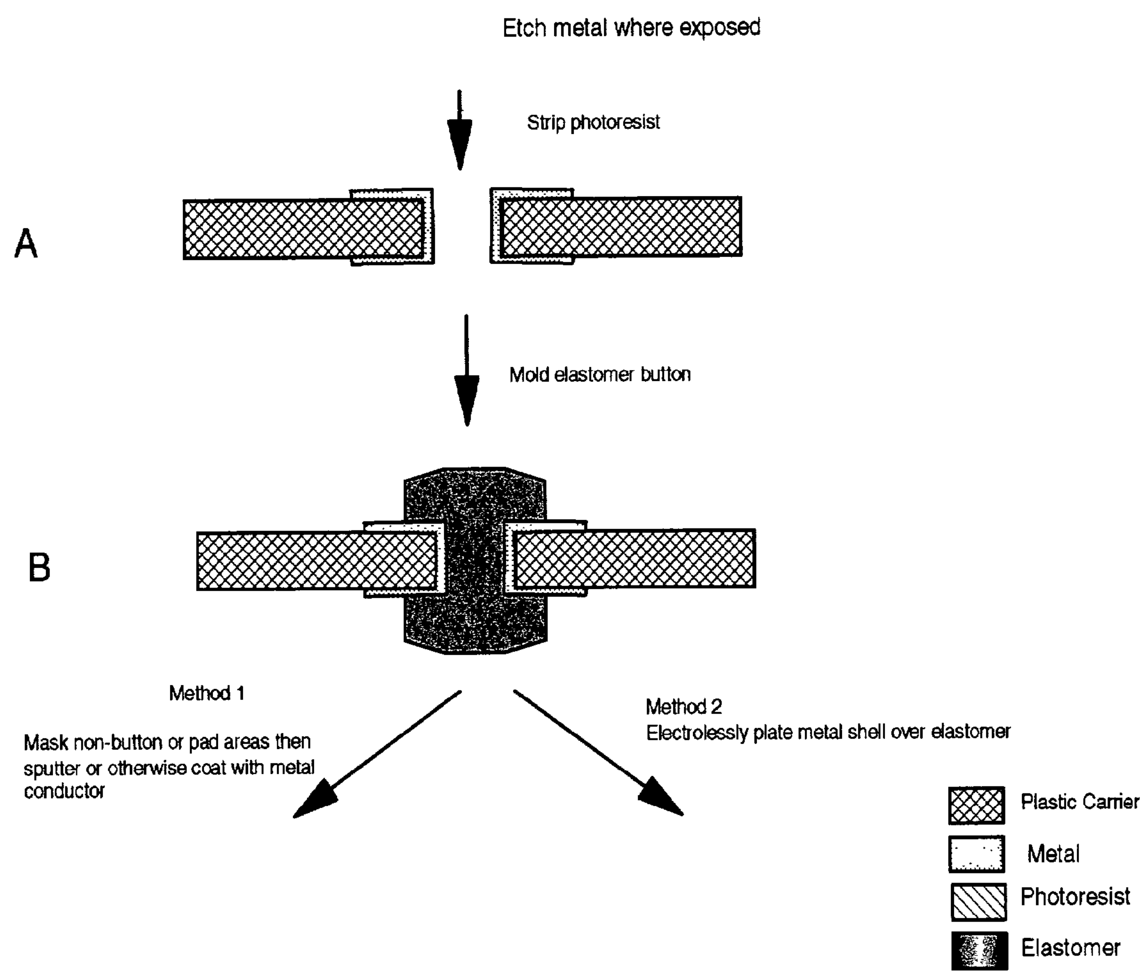


Figure 4: cont. from figure 3. Branch for method 1 to metallize the elastomer button to become conducting electrical contact

Method 1 - metalization through physical mask

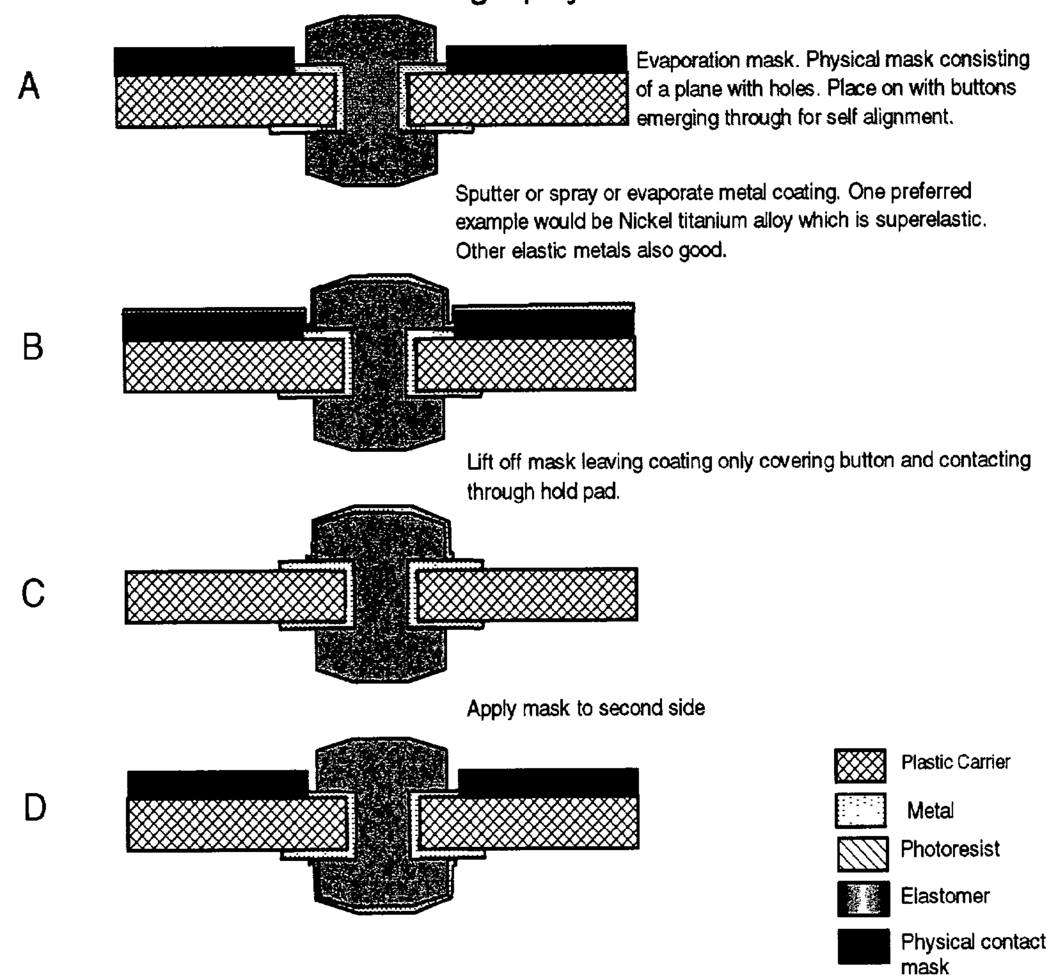


Figure 5: Method 1 continued to metallize second side of LGA.

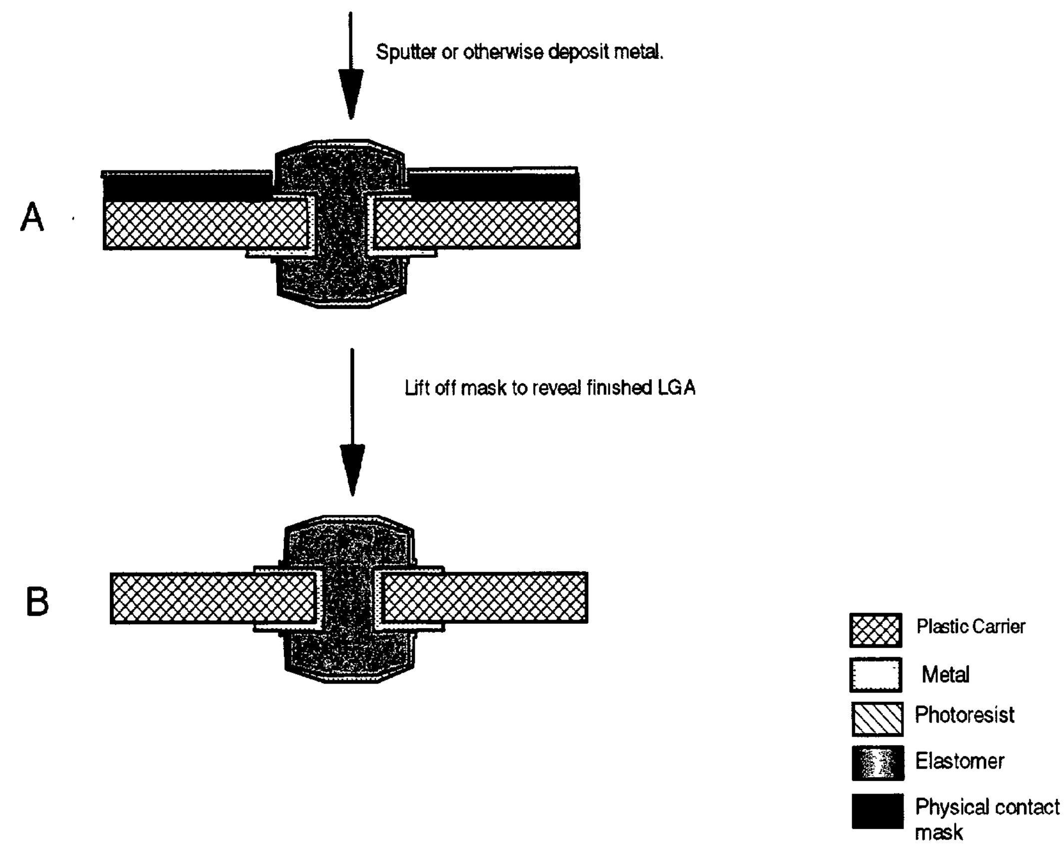
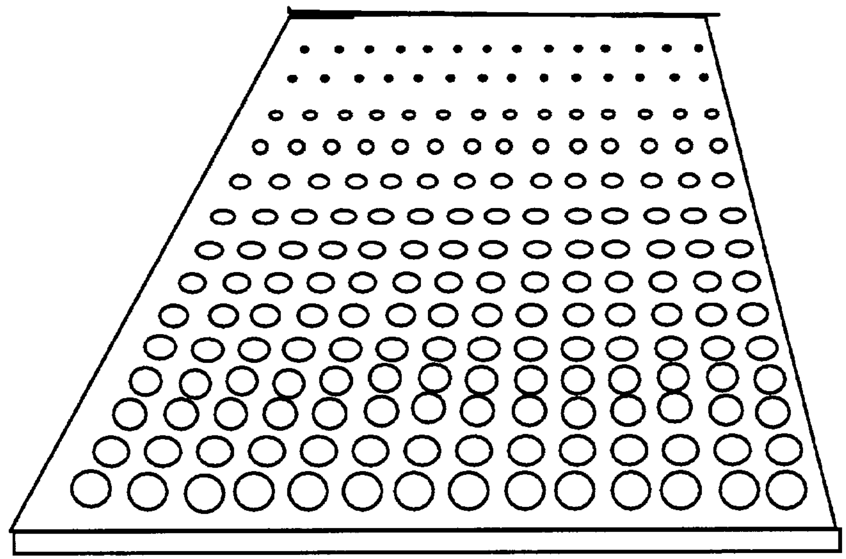


Figure 6 View corresponding to Figure 2-A



Plastic or Polyimide Carrier

Crossection view of empty interposer carrier plane
showing two example contact holes

Figure 7: View of empty interposer carrier corresponding to figure 2-A

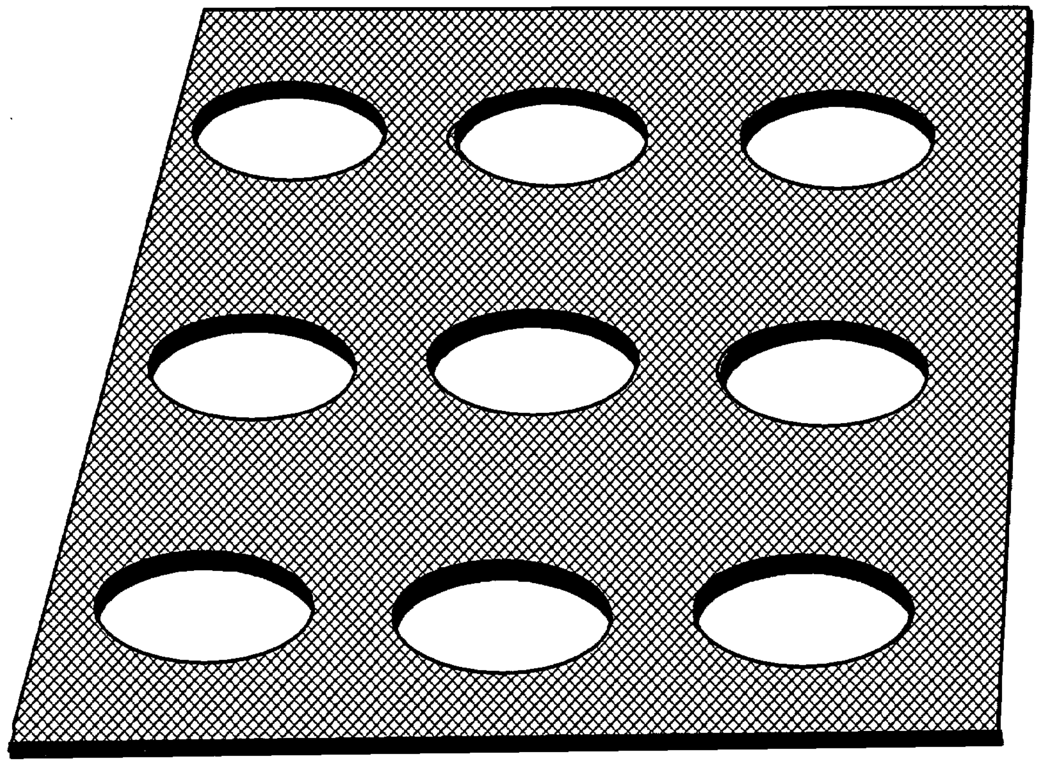
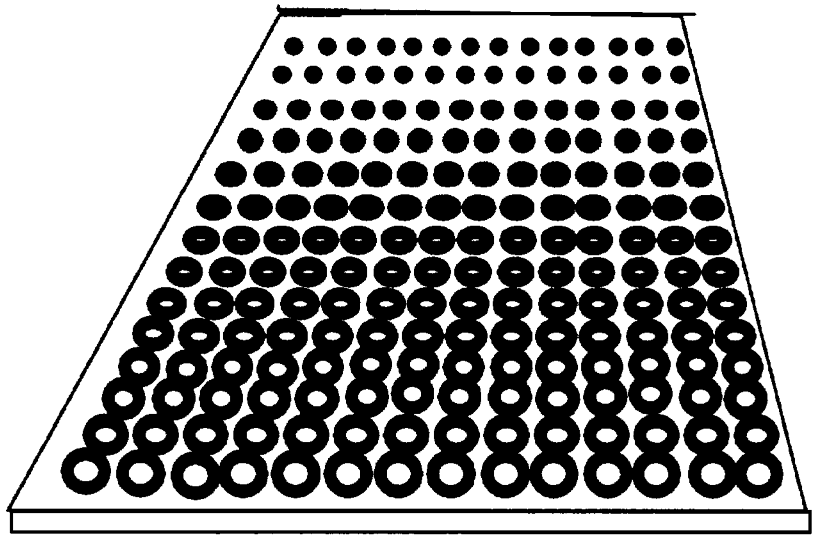
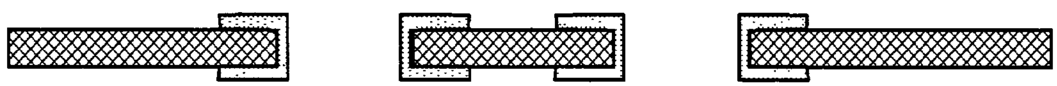


Figure 8: View Corresponding to Figure 2E





Crossection view of empty interposer carrier plane, with
continuous metal through-holes, showing two example contact holes

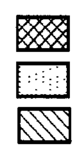
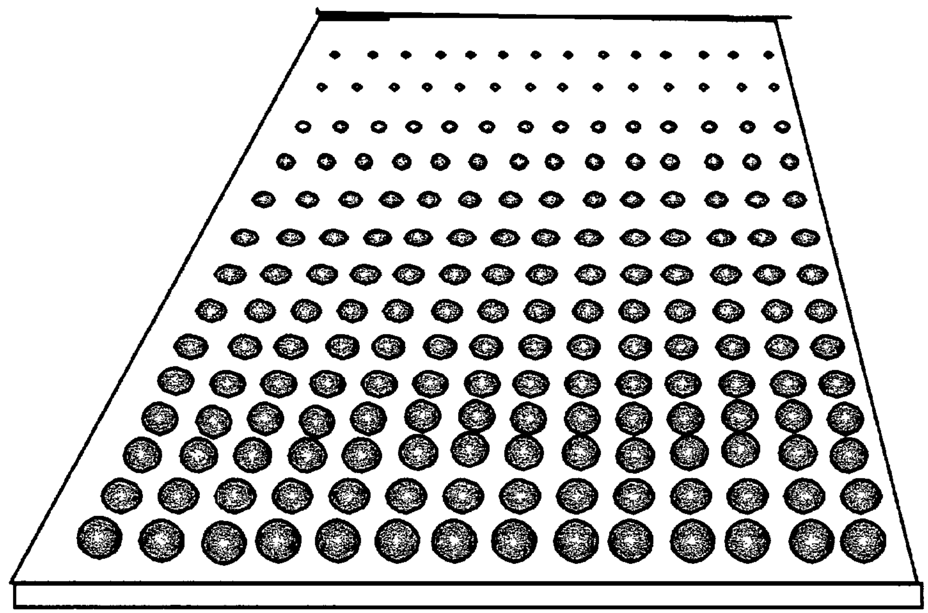
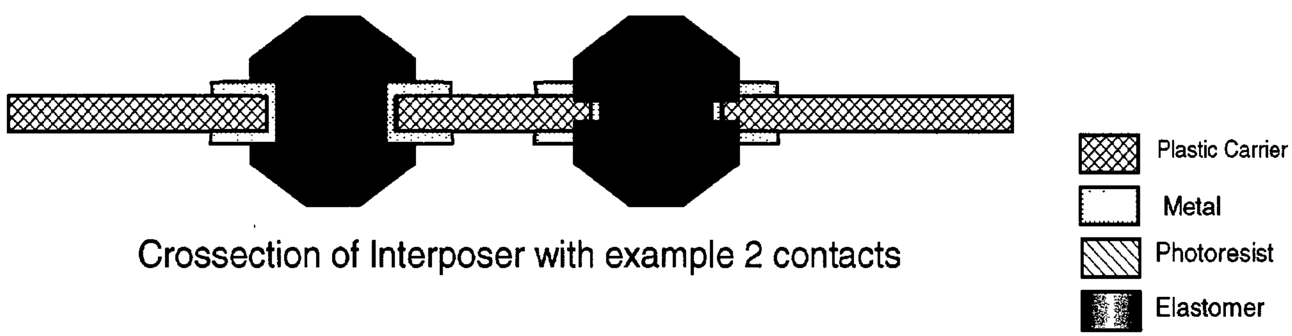


Figure 9: Corresponds to figure 3B



Perspective view of interposer carrier with contact holes filled with elastomer



Crossection of Interposer with example 2 contacts

Figure 10: View Corresponding to figure 3-B

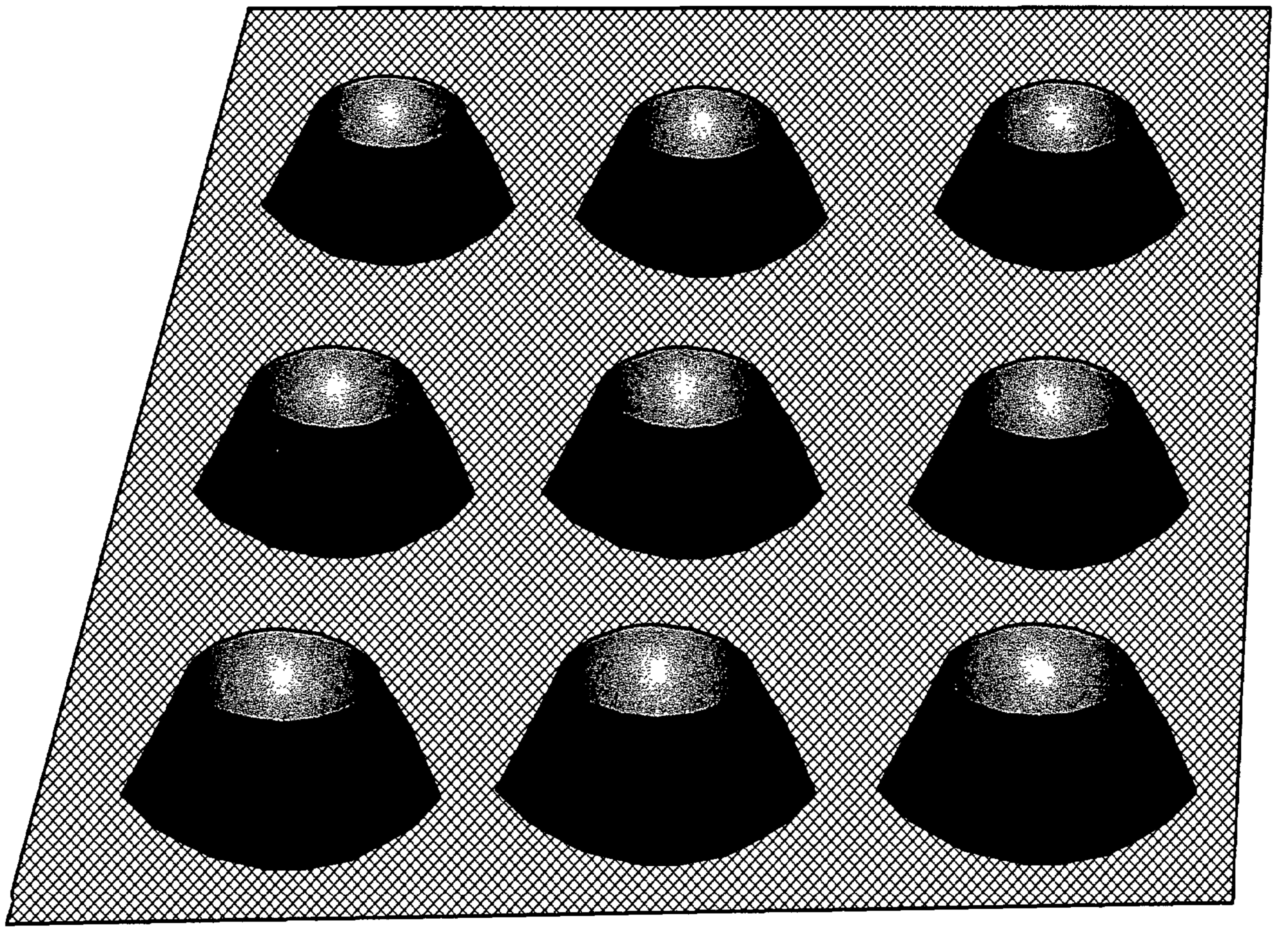


Figure 11: Example patterns of metallized siloxane button contacts after final fabrication is complete. Metallization pattern noncontinuous. Full metal cap shown in G for comparison. H is specialized electrode design with unmetallized hole in center to allow optical pathway for instances where vertical cavity laser may be located in place of a BLM

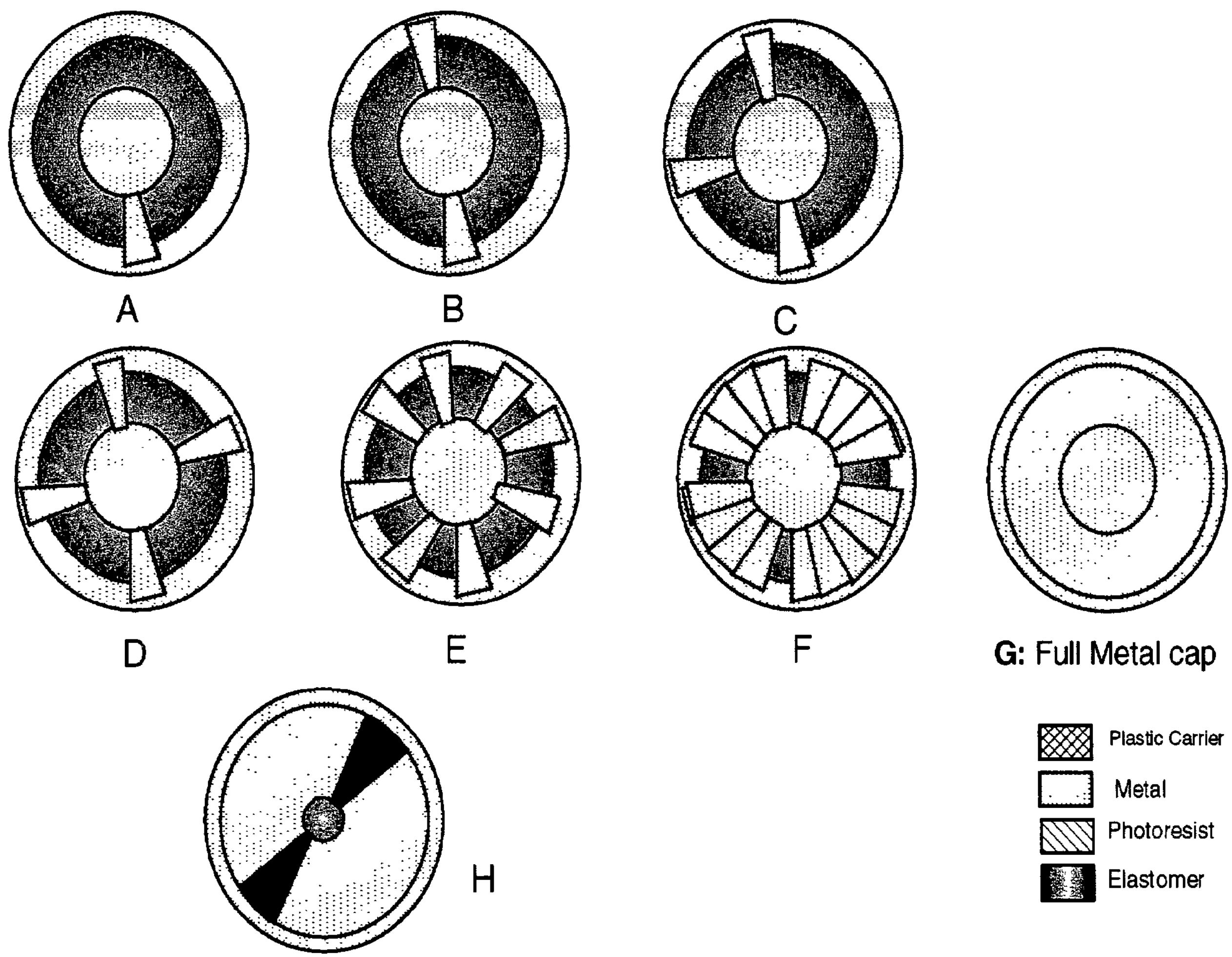
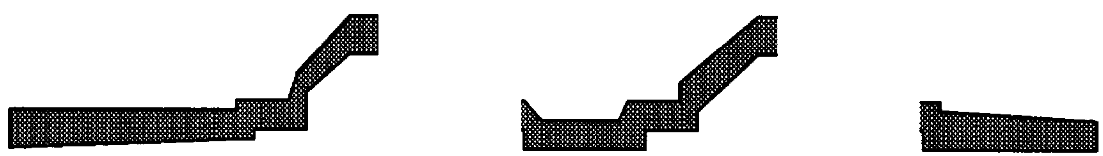


Figure 12: Physical contact masks for metallizing buttons

12-A

Mask to yield full metal shell
button. (two button positions shown.)
Mask corresponds to button type shown in figure 11-G

12-B



Mask to yield partially metallized
button (two button positions shown.)
Mask corresponds to crossection of button type shown in figure 11-A

Figure 13- Illustrating how unmetallized interposer is brought into contact with physical mask prior to metallization. Then metallization is carried out, mask is lifted away, and metallized interposer buttons remain.

(Example uses pattern shown in Figure 11-H which has additional optical window feature. Window consists of hole in metallization pattern to allow light from a VCSEL to pass
through to a detector.)

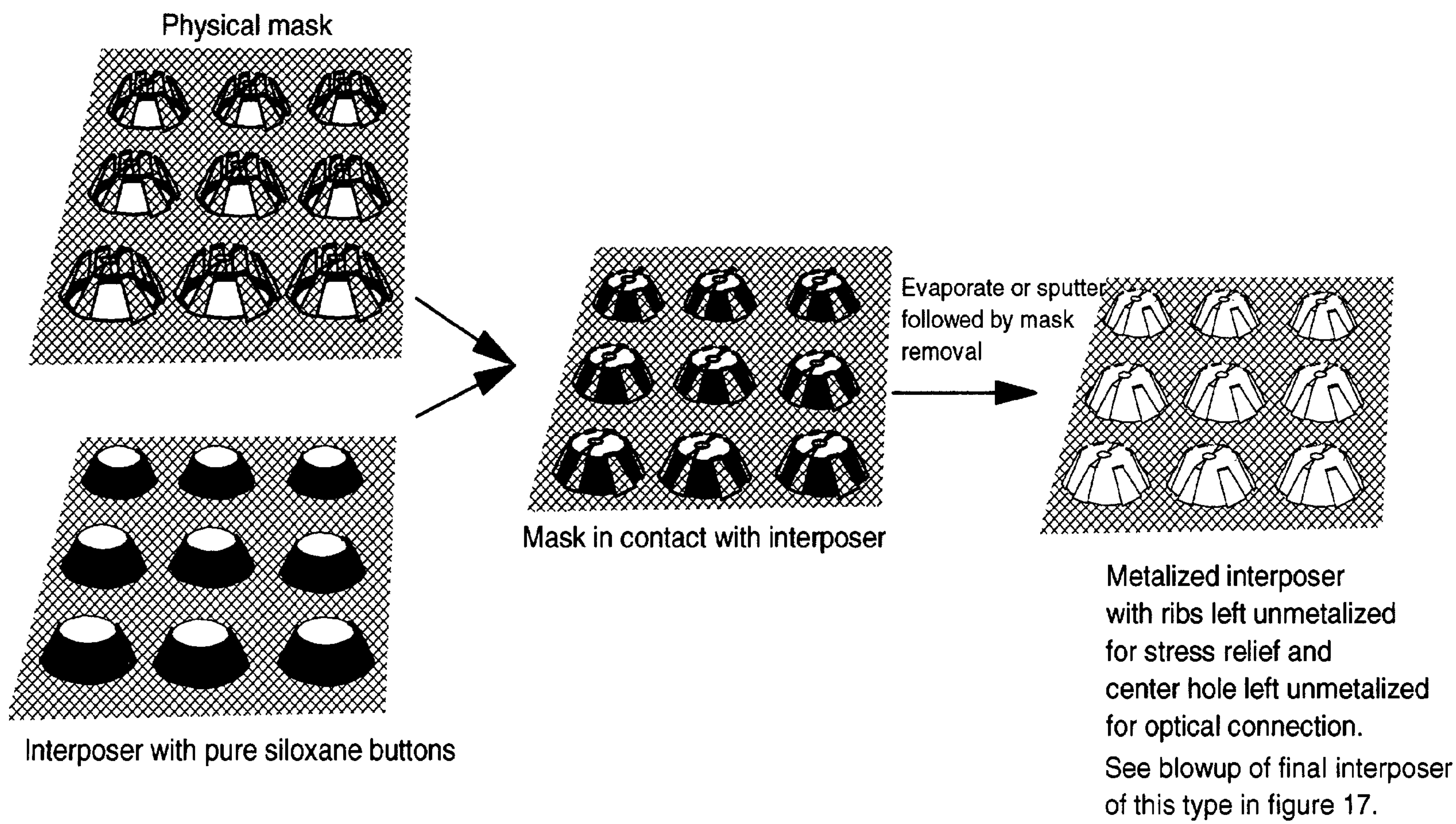
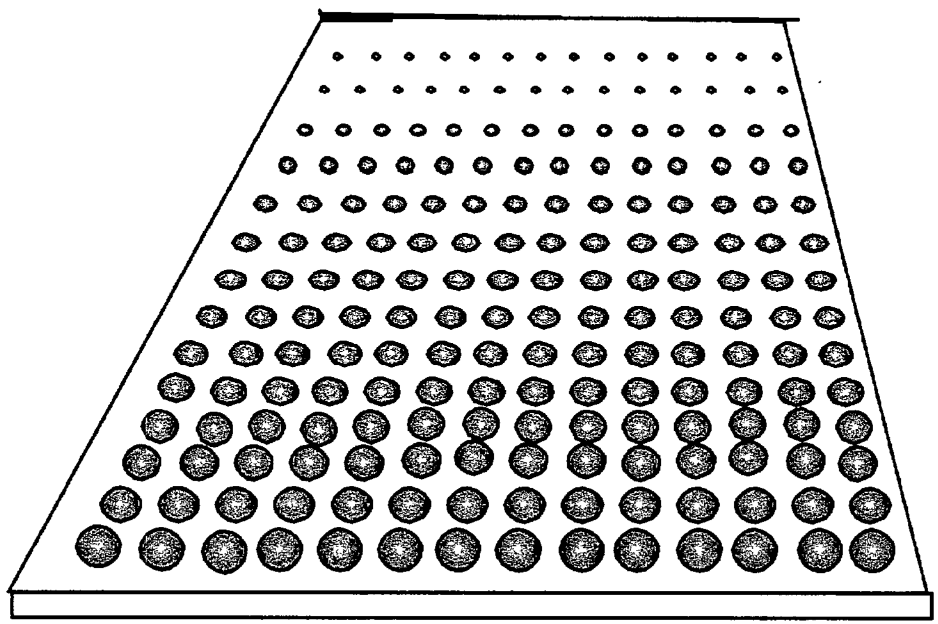
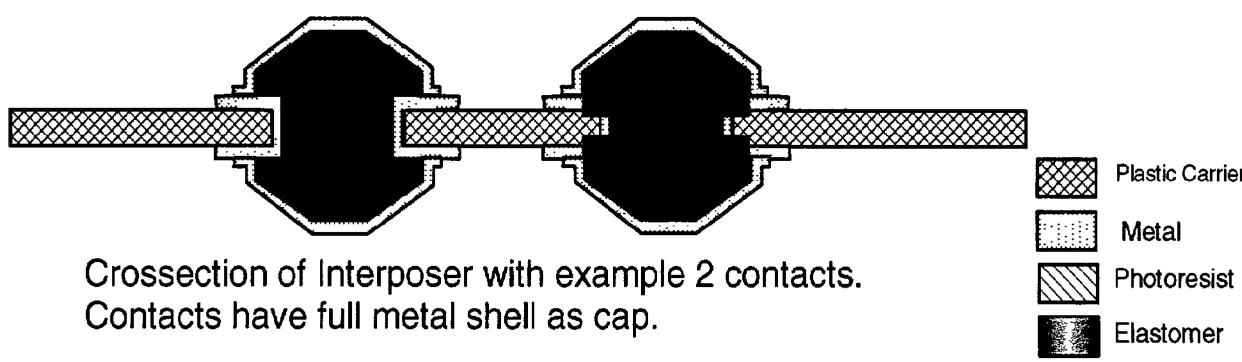


Figure 14: Corresponds to cap pattern in figure 11-G after all fabrication using mask of type shown in figure 12-A is complete.



Perspective view of interposer carrier with contact holes filled with elastomer



Crossection of Interposer with example 2 contacts.
Contacts have full metal shell as cap.

Figure 15: Illustrates an unmetallized array of siloxane LGA buttons docked into the physical mask corresponding to the pattern of figure 11-B.

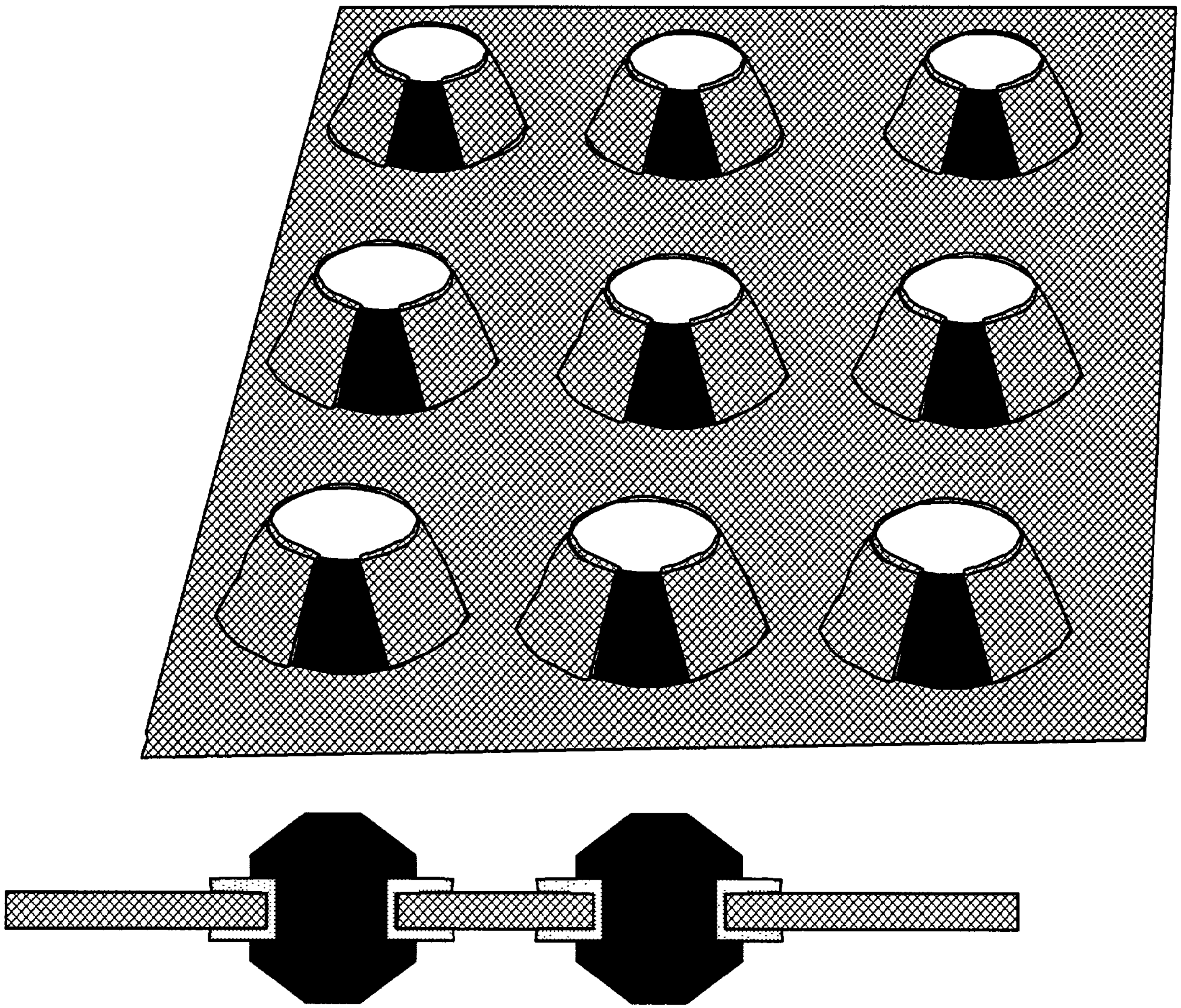


Figure 16: Illustrates an unmetallized array of siloxane LGA buttons docked into the physical mask corresponding to the pattern of figure 11-E.

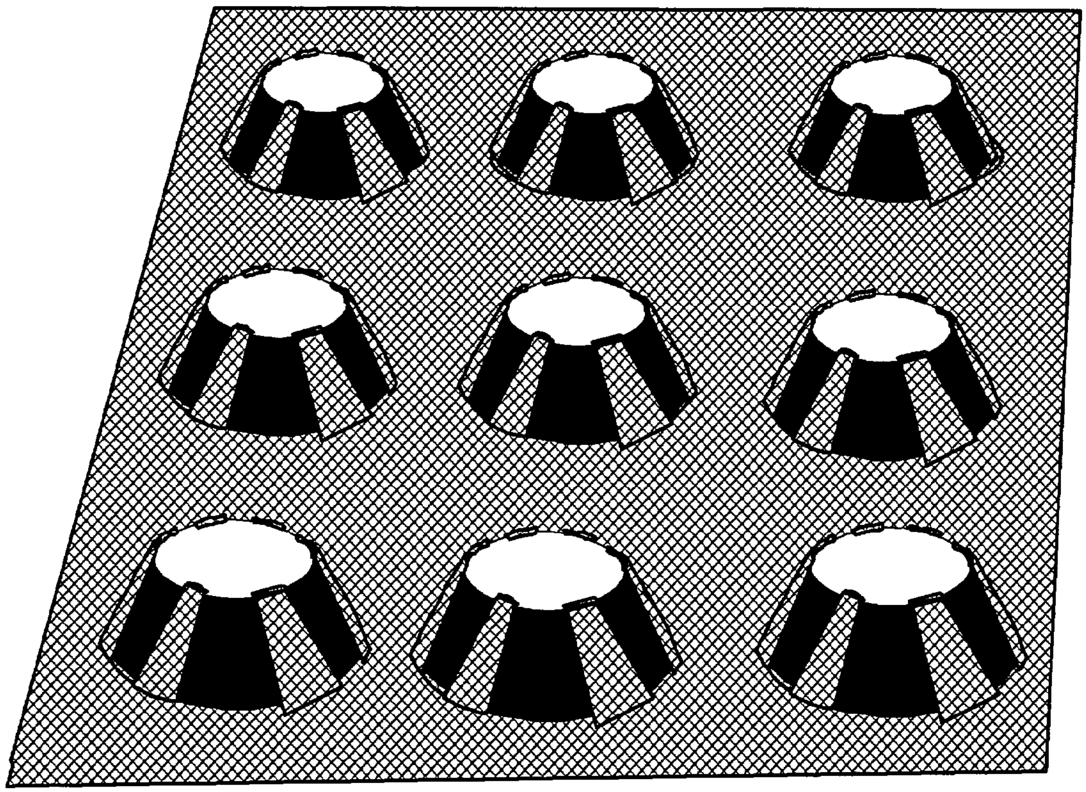


Figure 17: Final LGA interposer after fabrication.
Example pattern from figure 11-H.

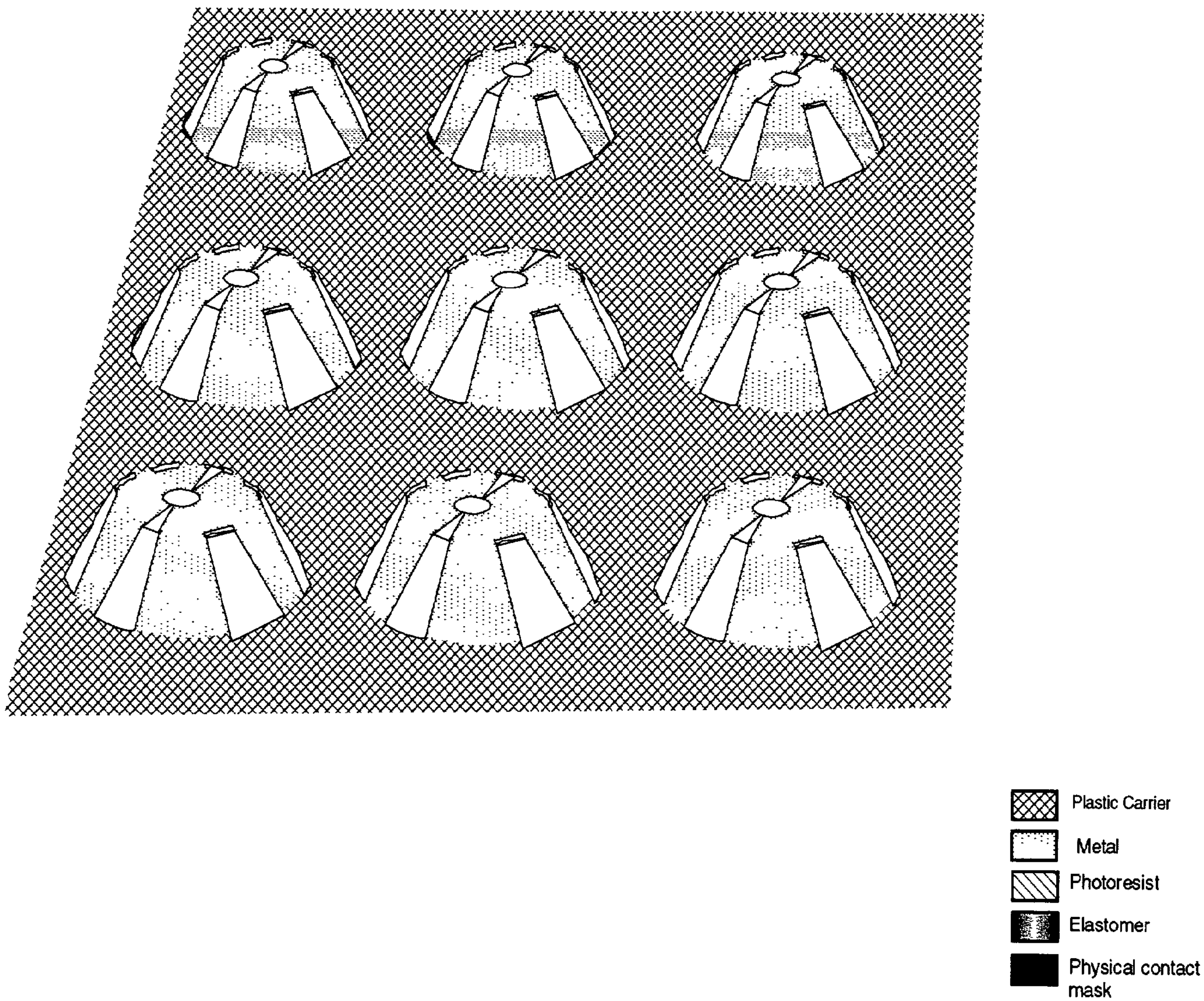


Figure 18: Method 2 for metallization of elastomer. Branch 2 of figure 3. Electroless plating using pre-seeded siloxane elastomer. No masks required for full metal shell type as illustrated in figure 11-G.